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ANALYTICAL HIERARCH PROCESS BASED TEMPORARY SHELTER SITE SELECTION FOR POST-DISASTER EMERGENCY SITUATIONS

Research

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Dr. Muhammet Enes Akpınar, Manisa Celal Bayar Üniversitesi, Endüstri Mühendisliği Bölümünde Araştırma Görevlisidir. Çok Kriterli Karar Verme ve Üretim Yönetimi üzerine çalışmaktadır.
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ABSTRACT

Purpose: Disasters are natural events that humanity can encounter at unexpected times. The unexpected occurrence of these natural events can bring with it many disasters. Undoubtedly, the way to get rid of this situation with the least damage after a disaster is to take precautions beforehand. Knowing the actions to be taken after an earthquake can allow the earthquake to end with the least loss of life. The selection of temporary shelter areas to be created after the disaster is one of the most important steps to meet the shelter and needs of people after the disaster. The selection of the temporary accommodation area may depend on many different criteria. Therefore, the selection of alternative temporary accommodation can be defined as a multi-criteria decision-making problem. This study aims to make an application on the selection of temporary shelter after a possible disaster and to decide on the most suitable alternative location.

Method: In the study, the analytical hierarchy process which is a multi-criteria decision-making method was used to solve the problem. In this method, pairwise comparisons of the criteria determined by the decision-makers are made. In addition, comparisons are made between each criterion and alternative, allowing the selection of the most appropriate alternative. This method was used in this study due to little information and uncomplicated processing steps.

Findings: In the study, the most suitable temporary shelter site was selected. Six different criteria were taken into account in this selection process (shelter size, distance to health centers, distance to city center, infrastructure, distance to social areas, and accessibility). Three different locations that meet these criteria have been identified as the most suitable. According to these determined criteria, the three most suitable positions were evaluated according to the analytical hierarchy process method. According to the findings, it was seen that the criterion of shelter size had the highest weight. In the evaluations made among the alternative locations, it was seen that the third alternative location was the most suitable place as a temporary shelter site.

Originality: In this study, the process of evaluating temporary shelter alternatives after a disaster is discussed. There are authorized boards for post-disaster interventions in our country. These boards are directly responsible for taking measures in case of natural disasters such as earthquakes and floods that occur suddenly both in provinces and districts. Therefore, thanks to this study, these committees will be able to determine scientifically alternative positions and ensure that people's lives are saved quickly in case of a possible disaster. In other words, this study is an exemplary study that can be applied in all provinces and districts in case of a possible disaster.

Keywords: Multi-Criteria Decision Making, Temporary Shelter Site Selection, Analytical Hierarchy Process

JEL Classification: M10, M11

ANALİTİK HİYERARŞİ SÜRECİ YÖNTEMİNE DAYALI AFET SONRASI ACİL DURUMLAR İÇİN GEÇİCİ BARINMA ALANI SEÇİMİ

ÖZET

Amaç: Afetler insanlığın hiç beklenmedik zamanda karşılaşabileceği doğa olaylarıdır. Bu doğa olaylarının beklenmedik zamanda gerçekleşmesi beraberinde birçok felaketi getirebilmektedir. Hiç kuşkusuz afet sonrası en az zararla bu durumdan kurtulmanın yolu önceden tedbir alınmasıdır. Bir depremden sonra yapılacak işlemlerin belli olması en az can kaybı ile depremin sonlanmasına imkan tanıyabilir. Afet sonrası oluşturulacak geçici barınma bölgelerinin seçimi afetten sonra insanların barınma ve ihtiyaçlarının giderilmesi için en önemli adımlardan birisidir. Geçici barınma alanının seçimi çok farklı sayıda kritere bağlı olabilmektedir. Dolayısıyla alternatif geçici barınma alanı seçimi bir çok kriterli karar verme problemi olarak tanımlanabilir. Bu çalışmada amaç olası bir afet sonrası geçici barınma alanı seçimi üzerine bir uygulama yapmak ve en uygun alternatif konuma karar vermektir.

Yöntem: Çalışmada problemin çözümü için çok kriterli karar verme yöntemi olan analitik hiyerarşi süreci kullanılmıştır. Bu yöntemde karar vericiler tarafından belirlenen kriterlerin ikili karşılaştırmaları yapılmaktadır. Ayrıca, her bir kriter ve alternatif arasında da kıyaslama yapılarak en uygun alternatif seçimine imkan tanımaktadır. Bu yöntem az bilgi ve karmaşık olmayan işlem aşamaları sebebiyle bu çalışmada kullanılmıştır.

Bulgular: Çalışmada en uygun geçici barınma alanı seçimi yapılmıştır. Bu seçim işleminde altı farklı kriter dikkate alınmıştır (kamp boyutu, sağlık merkezlerine uzaklık, şehir merkezine uzaklık, altyapı, sosyal alanlara mesafe ve ulaşılabilirlik). Bu kriterleri karşılayan en uygun üç farklı konum belirlenmiştir. Bu belirlenen kriterlere göre en uygun üç konum analitik hiyerarşi süreci yöntemine göre değerlendirilmiştir. Elde edilen bulgulara göre barınma alanının boyutu kriterinin en yüksek ağırlığa sahip olduğu görülmüştür. Alternatif konumlar arasında yapılan değerlendirmelerde ise üçüncü alternatif konumun, geçici barınma alanı olarak en uygun yer olduğu görülmüştür.

Özgünlük: Bu çalışmada bir afet sonrası geçici barınma alternatiflerinin değerlendirilmesi süreci ele alınmıştır. Ülkemizde afet sonrası müdahaleler için yetkili kurullar bulunmaktadır. Bu kurullar gerek illerde gerekse de ilçelerde ansızın yaşanan deprem ve sel gibi doğal afetlerde tedbirler almak için doğrudan sorumludurlar. Dolayısıyla bu çalışma sayesinde bu kurullar bilimsel açıdan alternatif konumlar belirleyerek olası bir afet durumunda insanların hayatlarının hızlı bir şekilde kurtarılmasını sağlayabileceklerdir. Diğer bir ifadeyle bu çalışma olası bir afet durumunda tüm illerde ve ilçelerde uygulanabilecek örnek bir çalışmadır.

Anahtar Kelimeler: Çok Kriterli Karar Verme, Geçici Barınma Alanı Seçimi, Analitik Hiyerarşi Süreci

JEL Sınıflandırması: M10, M11

INTRODUCTION

Disaster management plans short and long-term activities in case of any unexpected natural events. Various types of disasters such as earthquakes, storms, water, and floods are encountered on the earth. Being prepared for disasters will prevent possible losses and have an idea about how to act during a disaster. A fast and effective disaster management system should be developed to prevent the consequences of disasters and reduce their possible damages. For this purpose, it is necessary to determine the risks that may lead to disasters and to take the most appropriate measures to prevent these risks or to keep their damages at the lowest level. In this process, each individual has a role together with the most authorities. Besides, all organizations need to develop strategies regarding disaster management. The temporary shelter areas designated for disasters and emergencies play an important role in minimizing chaos and losses that may occur after an earthquake (Mojtahedi and Oo, 2017, p. 35).

Conducted under the coordination of the United Nations; The International Disaster Mitigation 10 years (1990-1999), which started in 1990, followed by the Millennium Development Plan-MDGs (2000- 2015), the Hyogo Action Plan (2005-2015), and finally, the Sendai Framework (2015-2030) (UNISDR, 2015) are global policies that guide disaster mitigation. In the Hyogo Action Plan, in disaster risk management; It is emphasized that all actors including governments, regional and international organizations, non-governmental organizations, volunteers, private sector, and academic environment should be in the process (UNISDR, 2005).

Sendai Framework states that governments have a primary role in disaster risk reduction, but this responsibility should be shared with other stakeholders, including the local government, the private sector, and universities. The Sendai Framework also highlights the importance of establishing and strengthening platforms in government coordination with relevant stakeholders at the national and local levels (Tsukahara 2017, p. 155). Under the auspices of the United Nations, the Sendai cooperation protocol or the "Sendai Framework for Disaster Risk Reduction" declaration can also be seen as the whole of planning activities that contain more comprehensive, long-term action plans compared to the Hyogo program and produce policies that reduce risks according to past experiences. In the Sendai declaration plan, four priorities were determined in general (Macit 2019, p. 175). These priorities are as follows:

- Understanding disaster risks,
- Strengthening management to cope with disaster risks,
- Investments in disaster risk reduction for fast return (recovery) from disasters,
- Improving disaster preparedness for better effective response, reconstruction, recovery, and rescue activities.

Disaster and Emergency Management Authority (AFAD) is the responsible organization for any kind of disaster in Turkey. In the event of a disaster, this institution prevents the growth of the disaster by intervening urgently with its teams in every province. AFAD teams that intervene in the events within two hours in the 6.8 magnitude earthquake in Izmir in 2020 play an extremely critical role. Many people survived thanks to AFAD's emergency responses. Undoubtedly, after the disaster, many people are directed to temporary shelter sites because they lost their homes. Temporary shelter areas appear that respond to human needs after any disaster occurred, and allow them to live humanely and safely. In emergencies such as disasters, water supply, nutrition, sanitation, and health measures have an important place along with shelter sites. From this, it is an important item that should be included in pre-disaster preparedness planning.

Post-disaster temporary shelter sites are safe areas that people should reach urgently during and after the disaster without any disaster risk. In other words, they are sites where disaster victims are informed and coordination is ensured with aid teams. These sites have some standards (Maral, 2016):

- Temporary shelter sites should be sufficiently close to settlements where they can be protected against external threats and dangers and where control and coordination can be provided.
- The areas to be established; be connected to electricity, water, and sewage networks.
- Planning the site for the establishment of facilities such as schools, kindergartens, markets, prayer areas, health centers, psychosocial support service centers, sports facilities, laundry, drinking water wastewater treatment facilities, playgrounds, course areas.
- Making the width of main roads at least 15m in temporary shelter sites and at least 10m width of side roads,
- Building a security controlled guardhouse at the entrance of the center,
- Paving the main roads of the neighborhoods to be established in the centers with asphalt or cobblestone,
- There should be at least 45 m2 per person in the shelter area, including infrastructure, roads, sanitation, schools, workplaces, water systems, security/assistance facilities, markets, storage facilities, shelter places.
- The shelter areas to be chosen for the disaster victims should be as close as possible to the residential areas.
- In terms of fire risk, a 30 m fire safety strip should be reserved every 300 m in the settlement area. To prevent adjacent buildings from collapsing, each household should have a distance of at least 2m (preferably twice the height of the building).
- Shelter areas should be treasury land, if possible.
- The settlement should be planned in a way to minimize damage to the environment.

The selection of these temporary shelter sites includes many different criteria. For this reason, this issue can be named a Multiple Criteria Decision Making (MCDM) problem. The problems that can be mentioned as site selection in the literature are as follows.

Vafaei (2014, p. 53) used the Analytical Hierarchy Process (AHP) method in the selection of mobile hospital locations for disaster situations. Kuo et al. (2002, p. 199) made a warehouse location selection using the fuzzy AHP method. Kocak and Calik (2020, p. 76) used the AHP methodology to evaluate the selection of bank alternatives. Vahidnia et al. (2009, p. 3048) determined the appropriate location for the hospital with the fuzzy AHP method. Athawale and Chakraborty (2010, p. 59) used the PROMETHEE method in the selection of the facility location. Tolga et al. (2013, p. 729) made the shopping center location selection using the fuzzy Analytical Network Process method. Akyüz and Soba (2013, p. 185) used ELECTRE management in choosing the establishment location for the textile industry. Akpinar (2016, p. 55) used AHP to evaluate university transportation system alternatives. Ar et al. (2014, p. 93) made a hotel location selection using AHP and VIKOR methods. García et al. (2014, p. 60), chose the warehouse location using the AHP method. Guler et al. (2014, p. 92) determined the place of establishment of the food industry enterprise. In other studies in the literature, Wiguna et al. (2016, p. 237) made a solar energy field area selection with fuzzy AHP and PROMETHEE. Wang and Liu (2016, p. 69) used the PROMETHEE method to determine the energy storage area. Sánchez et al. (2016, p. 387) selected the locations for solar farms using TOPSIS and ELECTRE methods. You et al. (2016, p. 16) determined the place of establishment with the ELECTRE method. Komchornrit (2017, p. 141) made a land terminal location selection using Confirmatory Factor Analysis, MACBETH, and PROMETHEE methods. Abdel-Basset et al. (2021) considered AHP and PROMETHEE II to location selection of wind energy stations. UTASTAR methodology is for warehouse location selection (Ehsanifar et al., 2021). Torkayesh et al. (2021) proposed BWM-grey MARCOS for landfill location selection.

In the disaster site selection literature, studies conducted according to disaster types differ. Disasters are divided into five different categories according to their solution methods (Ma et al. 2019, p. 399). CPLEX and Geographical Information System-based for hurricane disaster (Sherali et al. 1991, p. 439; Horner et al. 2018, p. 169), Genetic Algorithm (GA) and precise algorithms for Typhoon disaster (Pan 2009, p. 218; Pan 2010, p. 1727), Cplex and Simulated Annealing (SA) models (Kongsomsakul et al. 2005, p. 4237; Gama 2013, p. 11; Gama 2015, p. 25), Exact algorithms for post-earthquake situations and GA (Zhou and Jian 2001, p. 17; Hu et al. 2012, p. 1643) and different metaheuristic methods have been proposed for general disasters (Bozorgi-Amiri et al. 2012, p. 357; Yuan et al. 2015, p. 8; Du 2018, p. 15).

In temporary shelter site selection is proposed by using linear programming model (Hu et al. 2014, p 112), decision support model (Wex 2014, p 697), mathematical model (Bayram et al. 2015, p 146), TOPSIS methodology (Omidvar et al. 2013, p 536) and DEMATEL methodology (Trivedi 2018, p 722). Sengun (2007, p 1) researched disaster management after the Marmara earthquake. Omurgonulsen and Mentel (2021, p 159) proposed a fuzzy TOPSIS model to select temporary shelter sites for Ankara province.

In this study, a model is proposed for a post-disaster temporary shelter site selection. In this proposed model, 6 different criteria and 3 different alternative points have been taken into consideration for disaster site selection. With these criteria considered, it is aimed to decide on the most suitable alternative point. This problem is solved by the AHP method because of easy use and calculations. Besides, this method needs little information and considers pairwise comparisons. Hence, managers or decision-makers can get appropriate results even for complex decision problems. That is why this method is considered in order to select best temporary shelter site in this study.

The rest of the study is organized as follows: First of all, the analytical hierarchy process method used in the study is explained in detail. Then, the application of this method to the problem was mentioned. Finally, the results were interpreted and the most suitable alternative was decided.

ANALYTICAL HIERARCHY PROCESS

AHP is one of the most widely utilized methodologies for handling decision-making challenges. This methodology allows quantitative and qualitative variables to be analyzed simultaneously while taking decision-makers priorities into account. The AHP steps are as follows (Saaty 1980):

1st Step: The AHP approach begins by identifying the criteria to be investigated within the area of the problem to be addressed, as well as the sub-criteria that correspond to these criteria. The decision hierarchy is created when the criteria and sub-criteria have been specified.

2nd Step: Binary comparison matrices are created to determine the relative importance of the criterion. Decision-makers use the binary comparisons scale proposed by Saaty (1980).

3rd Step: The eigenvectors are created.

4th Step: Each comparison matrix is evaluated for consistency. In all comparison matrices, the consistency ratio should be determined.

5th Step: The relevance weights of the alternatives are displayed according to each criterion in the matrix. This matrix is multiplied with the matrix containing the importance weights of the criteria to give the ranking of the options.

CASE STUDY FOR DECIDING THE BEST TEMPORARY SHELTER SITE

In this section, a problem with the establishment of the temporary shelter area in cases requiring emergency response after disasters is mentioned. For the solution of this problem, the steps of the AHP method described the previous section have been applied practically. It has benefited from "Super Decision" software as software.

Problem Definition

In the problem, the problem of temporary shelter area selection in cases requiring emergency response after a disaster is addressed. In the literature, criteria that are generally taken into account when establishing the temporary shelter sites are accessibility, road connection, usability, public land, and area size (Aksoy et al., 2009; Tarabanis & Tsionas, 1999). For the solution of the problem, criteria are determined to decision-makers experience as well as literature (shelter size and accessibility). The decision-makers in the study consist of people who took part in the earthquake process and the data which are collected after the earthquake was determined consensus of five experts. It is aimed to decide on the most suitable one of the three different temporary shelter areas that can meet these criteria at the most appropriate level. The criteria determined by the decision-makers and their explanations are given in Table 1.

Table 1. Temporary shelter site selection criteria and explanations

Criteria	**Explanations**
Shelter size – C_1	The area should be as large as possible as there is an uncertain number of people after the disaster.
Distance to health centers – C_2	It should be close to these institutions for the health needs of those staying in the temporary shelter area.
Distance to the city center – C_3	It should be close to the center to reach the needed services.
Infrastructure adequacy – C_4	The area where the temporary shelter area will be built must have facilities such as electricity, water, and sewerage.
Distance to social areas – C_5	It should be close to Social activity areas that can make people forget the bad time they had.
Accessibility to the temporary shelter site – C_6	The temporary shelter area should be accessible by car, metro, and bus.

Selection of Temporary Shelter Area with AHP Method

The steps to apply the AHP method to the temporary shelter site selection problem mentioned in the previous section are explained in this section.

1st Step: Three different temporary shelter areas have been given by the decision-makers to meet the criteria at the most appropriate level. The hierarchy structure of these temporary shelter areas is given in Figure 1 and the areas are shortened as CS.

2nd Step: The importance levels of the criteria were determined by dual comparison and the results are given in Table 2. Then, the criteria were compared within each of them according to alternative temporary shelter areas and given in Table 3.

3rd Step: Eigenvector data were calculated for each criterion and the results are given in Table 4. Weight values for the criteria are provided in Table 5 while weights for the alternatives are provided in Table 6.

Table 2: Comparison of criteria among themselves

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
C_1	1,00	3,00	5,00	5,00	3,00	3,00
C_2	0,33	1,00	4,00	3,00	1,00	5,00
C_3	0,20	0,25	1,00	0,20	3,00	0,33
C_4	0,20	0,33	5,00	1,00	1,00	3,00
C_5	0,33	1,00	0,33	1,00	1,00	0,33
C_6	0,33	0,20	3,00	0,33	3,00	1,00

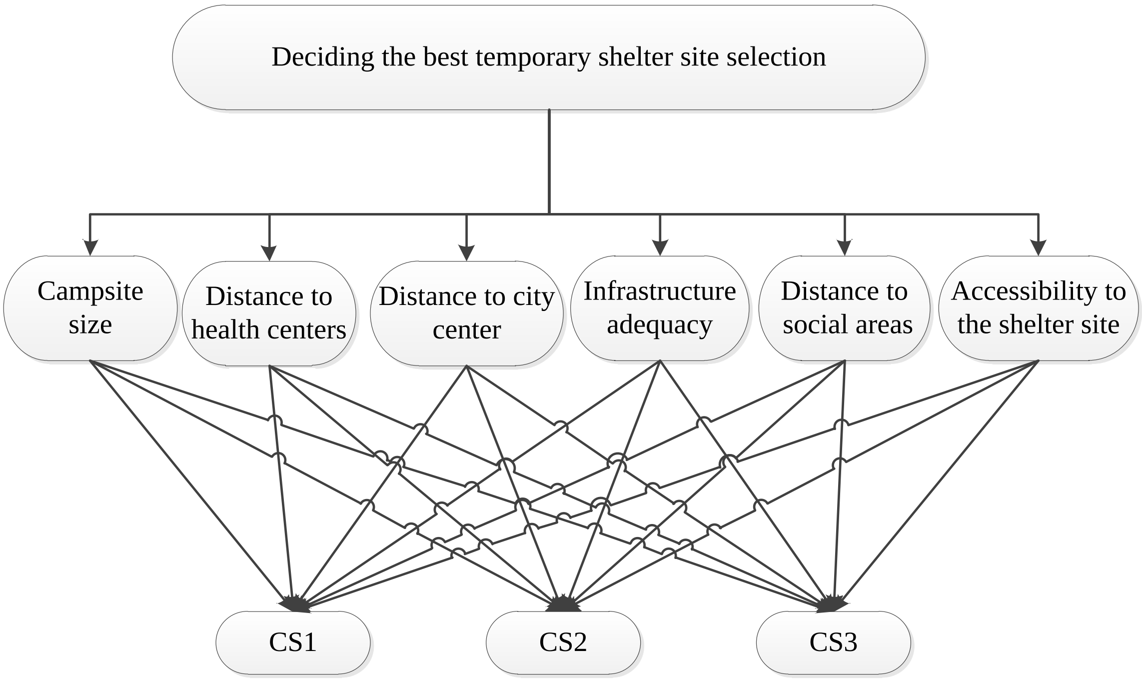

Figure 1. The hierarchical structure of the temporary shelter site selection problem

Table 3. Comparison of criteria concerning alternatives

	Shelter size				**Distance to health centers**				**Distance to city center**		
	CS_1	CS_2	CS_3		CS_1	CS_2	CS_3		CS_1	CS_2	CS_3
CS_1	1	1/3	1/5	CS_1	1	1/5	1/3	CS_1	1	1/7	1/5
CS_2	3	1	1/3	CS_2	5	1	1/5	CS_2	7	1	1/9
CS_3	5	3	1	CS_3	3	5	1	CS_3	5	9	1
	Infrastructure adequacy				**Distance to social areas**				**Accessibility to the temporary shelter site**		
	CS_1	CS_2	CS_3		CS_1	CS_2	CS_3		CS_1	CS_2	CS_3
CS_1	1	1/3	1/5	CS_1	1	1	1	CS_1	1	1/5	1/5
CS_2	1/3	1	1/3	CS_2	1	1	1	CS_2	5	1	1/9
CS_3	5	3	1	CS_3	1	1	1	CS_3	5	9	1

Table 4. Eigenvector values

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
C_1	0,42	0,52	0,27	0,47	0,25	0,24
C_2	0,14	0,17	0,22	0,28	0,08	0,39
C_3	0,08	0,04	0,05	0,02	0,25	0,03
C_4	0,08	0,06	0,27	0,09	0,08	0,24
C_5	0,14	0,17	0,02	0,09	0,08	0,03
C_6	0,14	0,03	0,16	0,03	0,25	0,08

Table 5. Weighting values of the criteria

	C_1	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	Weight
C_1	0,42	0,52	0,27	0,47	0,25	0,24	**0,36**
C_2	0,14	0,17	0,22	0,28	0,08	0,39	**0,22**
C_3	0,08	0,04	0,05	0,02	0,25	0,03	**0,08**
C_4	0,08	0,06	0,27	0,09	0,08	0,24	**0,14**
C_5	0,14	0,17	0,02	0,09	0,08	0,03	**0,09**
C_6	0,14	0,03	0,16	0,03	0,25	0,08	**0,12**

Table 6. Weight values of alternatives

Shelter size	Weight	Distance to health centers	Weight	Distance to city center	Weight
CS_1	0,10	CS_1	0,09	CS_1	0,05
CS_2	0,29	CS_2	0,37	CS_2	0,33
CS_3	0,61	CS_3	0,54	CS_3	0,61
Infrastructure adequacy	**Weight**	**Distance to social areas**	**Weight**	**Accessibility to the temporary shelter site**	**Weight**
CS_1	0,12	CS_1	0,33	CS_1	0,06
CS_2	0,14	CS_2	0,33	CS_2	0,27
CS_3	0,74	CS_3	0,33	CS_3	0,67

4th Step: Computing the eigenvector's consistency

For the consistency calculation, the AHP method was used and the consistency ratio was calculated as 0.082. Since this value is less than 1, the result can be interpreted as consistent.

5th Step: Obtaining the overall result of the hierarchical structure

As a result of the calculations, weights were obtained for each criterion and alternative temporary shelter area and the results are given in Table 7.

Table 7. Weights of criteria and alternatives

	C_1	C_2	C_3	C_4	C_5	C_6	Weight
Weight	**0,36**	**0,22**	**0,08**	**0,14**	**0,09**	**0,12**	
CS_1	0,10	0,09	0,05	0,12	0,33	0,06	**0.11**
CS_2	0,29	0,37	0,33	0,14	0,33	0,27	**0.29**
CS_3	0,61	0,54	0,61	0,74	0,33	0,67	**0.60**

According to the results of the calculations in Table 7, the highest weight in terms of criterion weight was calculated as "shelter size". The second most important criterion was "distance to health centers". Infrastructure adequacy, accessibility to the temporary shelter site, distance to social areas and distance to the city center are other highly important criteria. Considering the regions where the temporary shelter area is planned to be established, the third region is the region where the temporary shelter area can be established with the highest weight. The second and the first regions can be considered as other regions.

CONCLUSION, DISCUSSION, AND RECOMMENDATIONS

The post-disaster sheltering process is all of the processes in which the accommodation needs of the victims are met gradually. Emergency shelter needs of the victims are met during the emergency aid phase, which is the first step after the disaster occurs. Following the emergency aid phase, the rehabilitation phase begins, and at this phase, temporary shelter is provided until the production of permanent residences for disaster victims is completed. The process by which permanent residences are produced is the reconstruction process, and at the end of this process, victims return to their normal living conditions by acquiring permanent residences. The flow of all these processes is interdependent. Any failure that may occur at any stage will negatively affect not only that process, but the entire post-disaster accommodation process. For this reason, the organization of processes within and between each other is very important.

In this study, a problem related to location selection after the disaster has been solved. The AHP method, which is widely used in the literature, was used to solve the problem. Criteria and alternatives determined by the experts were evaluated among themselves. Finally, the alternative region that meets the criteria at the most appropriate level was decided.

With the results obtained in this study, a gap in the literature based on a city was filled. Besides, it has been observed that the AHP method can be used in the disaster management literature. The fact that this method is easy to use and can be solved in a short time means that it can be used to solve similar problems. The limitation of the study is that it is not known how this method will yield results if there are more criteria and decision-makers. This study can set an example in terms of literature and research and shed light on many future studies. This type of problem can be solved with different methods in future studies by using fuzzy data. According to the results of these fuzzy values, a new study can be created by comparing the data of this study. Simulation optimization algorithm, mathematical programming, and linear physical programming are other approaches for further studies to be suggested.

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